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OF THE

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AMERICAN WELDING SOCIETY
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COMPRESSED GAS MANUFACTURERS ASSOCIATION

The Compressed Gas Manufacturers Association will hold its twelfth annual meeting on Jan. 26, 1925, at the Hotel Astor, New York City. The meeting will be followed by the annual dinner the evening of the same day.

This Association represents manufacturers of all industrial gases, such as acetylene, ammonia, carbonic gas, chlorine, hydrogen, nitrous oxide, nitrogen, oxygen, sulphur dioxide and various hydrocarbon gases. These gases are used for isolated lighting and heating plants, in the fabrication of metal by means of the welding and cutting torch, for mechanical refrigeration, for carbonation of beverages, for bleaching in the textile and paper industries, in the purification of water and sewerage by chlorination, as anaesthetics, in fire extinction, and for various other purposes. The Association studies principally the technical problems involved in the transportation of gases under pressure, the methods of insuring the establishment of safe practices, and the possibility of extending the uses of the compressed gases in industry.

ANNUAL MEETING

Preparations for the annual meeting are already under way. It has been tentatively proposed by the Meetings and Papers Committee to devote the technical session to a symposium on the inspection of welds and testing the skill of welding operators.

Methods differ widely for different industries. For example, it is readily conceivable that the method of inspection for welding of cast iron and testing the skill of operators by either the gas or electric processes would be totally different from methods used on production work in welding steel barrels.

A number of industries have been selected and recognized experts of these industries will be requested to prepare brief papers covering their fields. Further details will be announced later.

AMERICAN MUSEUM OF SAFETY

We have been asked to announce in our Journal that the American Museum of Safety, 120 East 28th Street, New York City, is open daily from 10 a. m. to 5 p. m. and on Saturday from 10 a. m. to 12 m.

Members are cordially invited to visit the Museum when they are in New York. Copies of their magazine on Safety will be sent upon request to Mr. A. A. Hopkins, Director of the American Museum of Safety, whose office is located at 141 East 29th Street, New York City.

BOUND VOLUMES OF THE JOURNAL

A limited number of bound volumes of the Journal for 1924 will be made up shortly, which members may obtain at $5.00 per copy. As the supply is quite small, it is suggested that members place their orders as soon as possible.

SECTION ACTIVITIES

Boston Section

The next meeting of the Boston Section of the American Welding Society will be a joint meeting with the National Association of Stationary Engineers and will be held at Franklin Union Hall, Berkeley and Appleton Streets, Boston, Mass., on Dec. 19. Mr. S. W. Miller of the Union Carbide and Carbon Research Laboratories will present a paper on the "Acetylene Welding of Cast Iron with Bronze." In addition two interesting demonstrations of gas welding are being prepared.

Western New York

The November meeting of the Western New York Section was held on the 12th at Mechanics' Institute, Rochester, N. Y. Mr. W. P. Madden of the General Electric Company presented a paper on the "Application of Arc Welding with the Automatic Welding Machine." His lecture was illustrated with a number of lantern slides showing the many applications and the high production speed possible with the automatic welding machine. A moving picture of the electric welding arc in action magnified 300 times was also shown.

The December meeting was held on the 17th at the lecture room of the Seneca Vocational School, Buffalo, N. Y., and among those present were included welding shop proprietors, engineers of welding, superintendents, managers of industrial plants, welders and students. Mr. James Burke, president of the Burke Electric Co., presented a paper on "Manufacturing Applications of Electric Welding." A number of slides were shown illustrating many examples of welding in the shops of the Burke Electric Co. Among other things, the entire steam heating equipment of this plant has been electrically welded.

The next meeting of the Section will be held on Jan. 14, 1925, at which time Mr. S. W. Miller of the Union Carbide and Carbon Research Laboratories will present a paper on "How Heat Affects Steel, Especially in Welding."

San Francisco

The November meeting of the San Francisco Section was held on the 21st in the Engineers Club. Mr. R. E. Lamberson presented a paper on the "Problems and Needs of the Job Welding Shop."

Pittsburgh

The November meeting of the Pittsburgh Section was held on the 21st. Mr. T. T. Copeland of the Carnegie Steel Co., Homestead Mills, presented an illustrated paper on "Reclaiming Worn and Broken Parts in Machinery."

The following schedule for future meetings is reported by this section:

December—Seward W. Mann, H. Kleinhaus Co.

January—Lincoln Electric Co.

February—L. H. Burkhart, chief engineer, Struthers-Wells Co., Warren, Pa.

March—Stanley Crute or Representative, Advance Welding Co., Coraopolis, Pa.

April—Burke Electric Co., Erie, Pa., Mr. Burke or Mr. Boyd.

Philadelphia

The December meeting of the Philadelphia Section was held on the 15th. Among the speakers were scheduled the following:

Mr. Eric H. Ewertz, general manager, Bethlehem Shipbuilding Corp'n, Ltd., Moore Plant, Elizabeth, N. J.

Dr. George L. Kelley, director of laboratories, Edward G. Budd Mfg. Co. and Budd Wheel Co., Philadelphia, Pa.

New York

The December meeting of the New York Section was held on Dec. 16. Mr. F. C. Fyke of the Standard Oil Co. of New Jersey presented a paper covering their practice in welding pipe lines, refinery and tank work. A large number of slides were shown. The paper was discussed by a number of prominent experts in the oil field.

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EMPLOYMENT SERVICE BULLETIN

Opportunities.—The Society is glad to learn of desirable opportunities from responsible sources, announcements of which will be published without charge in the BULLETIN.

Services Available.—Under this heading brief announcements (not more than seventy-five words in length) will be published without charge to members. Announcements will not be repeated except upon request received after an interval of three months; during this period, names and records will remain in the office reference files.

Note.—Copy for publication in the BULLETIN should reach the Society's Office not later than the thirtieth of the month if publication in the following issue is desired. *ALL REPLIES should be Addressed to the number Indicated in Each Case and Mailed to Society Headquarters.*

Positions Vacant

V-18. Acetylene welder wanted in Philadelphia, experienced in all metals. Full particulars first letter, hourly rate and names of employers for past three years. Electric welding knowledge helpful but not essential. Expenses refunded if competent after three months.

V-19. Electric welder wanted in Philadelphia with cast iron experience. Full particulars first letter, hourly rate and names of employers for past three years. Acetylene welding knowledge helpful but not essential. Expenses refunded if competent after three months.

V-20. Wanted. Acetylene welder with experience in electric welding to take charge of production shop. Give full particulars of past experience and present employment in first letter. All information will be treated confidentially.

V-21. Twelve good welders needed for pipe line welding. Will pay $250 U. S. currency per month and living expenses in camps in the oil fields of Tampico, Mexico, and will refund railroad fares to any welder after four months.

Services Available

A-28. Demonstrator and Salesman available. Regular go-getter with 8 years' practical experience on oxy-acetylene torch and regulator repairs, etc. Am 27 years of age, married and can furnish first-class references from several of the leading equipment firms of the U. S. A. Desire opportunity where hard work and good results are appreciated. Southern states preferred.

A-29. Experienced welding supervisor desires position. Have had 14 years' experience with electric arc welding; 3 years in production work in car shop, both coach and freight; 3 years heavy repair welding, 3 years demonstrating and selling welding equipment, 1 year soliciting, estimating, directing and inspecting repair welding and 4 years in my present occupation in charge of welding. Desire position with railroad shop as assistant to Master Mechanic in charge of welding or with manufacturing concern as efficiency man to reduce manufacturing cost by welding, or with a welding firm selling, demonstrating and installing welding equipment or welding supplies. Can furnish references. Have no objection to travel.

A-30. Expert supervisor desires connection. Have had 9 years' experience; 4 with oxy-acetylene welding in railroad and jobbing shops and 5 in electric welding. Have supervised welding on some of the largest pipe lines in the U. S. Have made a special study of electric welding of cast iron. Am now employed as supervisor and instructor for a large company.

Discussion of Papers Presented at Fall Meeting of American Welding Society, Cleveland, October, 1924

(Papers published in the October and November, 1924, issues, Journal American Welding Society)

Discussion Paper "Use of Electric Arc for Welding Structural Steel" by R. B. Kinkead, Engineer, Arc Welding, Lincoln Electric Company.

W. Spraragen (American Bureau of Welding): In this test on rubber Mr. Kinkead speaks of, were the rivets made of rubber, too?

R. Kinkead: Yes, sir.

F. E. Rogers (Air Reduction sales): I would like to ask Mr. Kinkead if the results of his experiments threw any light on desirable modifications in our conventional steel members for welding?

R. Kinkead: Mr. Chairman, the purpose of our experiments with rubber sections was quite different from that. We were trying to get a fundamental physical conception of what goes on in a riveted joint. We found our own physical conception was distinctly lacking in that direction. The subject of modification of the standard steel sections to meet the requirements of welding is one which will require a great deal of study. It is a separate question. Most of our sections have been designed primarily for the riveting process. For instance, in the use of angles, as a rule, only one leg of the angle works and the other is merely a place to drive rivets.

T. Wry (General Electric Company): What is the maximum elongation you have been able to get in the welded joint?

Mr. Kinkead: The most I have ever seen is 18 to 20 per cent and that was obtained with the English slag covered welding electrode.

Discussion of paper on "Oxy-Acetylene Welding and Cutting in Structural Field." G. O. Carter, Consulting Engineer, Linde Air Products Company.

L. H. Burkhart: I'd like to ask Mr. Carter for a little more detail of how he alloys the flux in making those welded joints with bronze?

Mr. Carter: For the bronze filler we use a flux which might be called abrazo flux which has been used for a long time in the welding of cast iron with the bronze filler. That is a process of many years' standing. The welder simply heats the end of his filler rod, dips it in the flux, then applies the flux to the steel where he wants to make the weld. He has to bring it to the proper temperature. As a rule, the temperature is brought to a visible red before he touches the flux to the material. If the flux spreads he has reached

the right temperature. If the flux simply lies as a powder he hasn't as yet reached the right temperature and he simply waits until he has the temperature, which is only a matter of a second or two. Then as soon as the flux has spread the bronze itself will melt down and you will find that the part is tinned where the temperature has been right and in the bronze welding that is a constant temperature. Simply play the torch an inch or two ahead, then come back and fill in.

I may say there are developments being worked out which are very logical in that we can get away from the fluxing by having material prepared at the mills by either having a machine surface which will then be just dipped in the molten bronze and will be tinned instantaneously. That is the way of making brazed tanks nowadays. On the other hand, the plates may require a little pickling, in which case they will be dipped in the pickle and then carried right over and dipped in the bronze. It can be made so when the material gets to the field all a man will have to have will be his bronze filler rod. This bronze will melt almost like pouring water. To stand and watch the speed with which it is applied is very interesting and impressing.

W. Warner (General Electric Company, Schenectady): Mr. Carter made a statement about tubular structural forms. I would like to ask what information and test data he has on that. If he hasn't it what kind will be needed to design a structure or bridge made completely of these tubular forms? If he has that information, couldn't he design a small truss with appropriate discussion for printing in the journal so we can have a chance to compare the two? I think it would be very interesting information.

Mr. Carter: I agree with Mr. Warner. I think this is one of those things we can undertake. It is part of our activity. Many trusses have been designed, not for bridges but for buildings. The Prairie pipeline, for instance, has been using that form of construction for the pumping stations and the warehouses. I will show two or three typical slides which show quite an extensive warehouse made of tubular construction. The strength of tubes can be readily obtained from the National Tube book of standards.

I really feel that this is the place where things of this kind have to be threshed out. There may be a question of the oxy-acetylene versus electric. Nevertheless, there are certain costs, certain qualities that can be matched one against the other so we feel the Welding Society as an organization can and must be back of this thing before the engineers of the country are going to be back of it.

People like the Foundation Company, J. G. White, and numerous other companies, are watching the possibilities of this development with very keen interest. Their operating executives are beginning to believe in it so it is only a matter of time to bring this extension about if we formulate our own ideas and get busy.

Yesterday I was very much impressed with two things. I was

impressed in the visit to the Collingswood shops, that there was an apparent distrust of welding and the very small amount that was being done there. Many people who are responsible for maintenance and repair work are afraid if the welding goes bad they are going to be severely condemned for it. Therefore they don't weld.

The second thing I saw yesterday was at the Lincoln plant, where the Lincoln people are studying ways to use the welding process. We ourselves have been trying to do that for several years.

About three years ago we had one welder at our head machine shop in Buffalo. We weren't sure that we could keep two men busy, so as a matter of policy we thought we would take on a man. If we couldn't keep him busy he wouldn't be much worse off than before he answered our ad, We then added a second welder, and it wasn't long before the first fellow was foreman and had six or seven men working for him. Last winter that welding crew was kept busy fabricating pipings in the Linde plant. We set meters on a lot of equipment tanks and things of that kind and generators and piping that goes in the Prest-O-Lite plants. We average the construction of about one small manufacturing plant a month, and we were using in our own organization from 23 to 28 welders fabricating that material where we had been in doubt as to whether there was enough welding there for one.

We had to go back into the design—back into our drawing office and started them studying and answering the question, "Can this joint be welded?" "If it can be, then why isn't it being welded?" That is how we built up that organization and the operating fellows of the plant are just tickled to death with it. The men in all of these plants have a minimum of trouble where we have the welded construction and we have had no serious failures.

The Lincoln visit impressed me because it was exactly along the lines of what our own people have been doing for three or four years, and I think that is one way we can all of us boost welding. If we haven't faith in our own product, who will have?

A. G. Oehler (*Railway Age*): Can you tell us, Mr. Carter, something about the relative cost of bronze welding as compared with steel?

Mr. Carter: Bronze welding is half of the cost of steel welding. The bronze is applied so much faster it cuts your labor charge way down, and the other charges come down somewhat. The total cost in the ratio is about 85 to 150. It wasn't quite half—85 for bronze and 150 for steel.

A. G. Bissell (Westinghouse Electric & Mfg. Co.): Can you tell us approximately what the composition of that bronze is? We are interested in composition, as we are running tests on arc welding of bronze.

Mr. Carter: The bronze we have been using is Tobin and it

works quite satisfactorily in some places. We are working on bronze fillers. We have every reason to believe that there are several compositions that are better than Tobin. It is a little premature to give any composition and they are not on the market as yet, but we are doing a good deal of research to get the right materials.

Mr. Lincoln (Lincoln Electric Co.): The biggest thing and the next step in this matter of welding structural steel, is getting some information we can give to engineers. Suppose we have got a column over here with a million pounds of stress on it. How much welding have I got to put in to take care of those million pounds? Mr. Carter, have you ever made any tests? Can we tell them if they take a $\frac{3}{8}$-in. plate how much they will have to weld it to get the proper strength?

Mr. Carter: We believe in butt welding. We believe it has been demonstrated to be the best. I think that applies to electric as well as gas.

Mr. Lincoln: We have got it down to a practical proposition. You have a column and one very definite proposition comes up. This man said he had a column 20 ft. apart and wanted 25 ft. on the first floor of the building for the entrance. He has to transfer that million pounds over about 4 ft. He is going to put a bracket up there.

Mr. Carter: If he brought me a problem to that effect I'd sit down and do some calculating. I probably would tell him, "I don't believe in that design." I wouldn't want to be responsible for that design.

Mr. Lincoln: Don't you think the first thing to be done would be to start welding on the buildings as they are made now?

Mr. Carter: No, because we are already doing a great deal of welding tubular construction. I think that is going to be carried forward because it will save them a great amount of steel by the use of tubular construction, a saving in tonnage. There is every reason why they should study design. Five years ago we took hold of this problem of welded pipe. There was a great deal of welded pipe in the country that was giving excellent results, but very few relatively were using welded pipe. This summer we finished welding 215 miles of pipeline in Texas, of 14, 16 and 18 in. in diameter. The minimum test on the 18-in. pipe per square inch was 550 lb. pressure and we had upward of 200 welders working at the peak. Now that was the result of what we believe was the correct way of doing that work. We didn't take any old design. We started building on what was correct from a welding point of view. Then there was a big question, "Can you do these jobs fast enough?" Frankly, that is one of the things that is disturbing construction engineers. Now they can throw a big crew of iron workers in on the job and it goes right on up. Every day we stand and watch these structures climb.

The managements of these big construction companies are afraid they can't get enough welders. We had that job to contend with there in Texas. We employed welders with experience and we made welders out of men who were in the refinery and wanted to earn welder's wages and were willing to go in and train for it. Incidentally, they knew that east Texas country, which is beastly country to work in. We were glad to get some fellows like that in the gangs. We also took high school boys who wanted to go out and work for the summer. One youngster they called Peewee went through the whole summer without a single defective weld until the very end of the work when the foreman of the gang insisted on the welders working when they said conditions weren't right. The welders were correct in stating that conditions weren't right. The youngster fell down and made his first defective weld.

From the gas end we are getting a return from the sale of the gas that warrants us in giving the service, and it is my belief that that is the only way that some of these things have been brought about in the last three to five years.

Now, if you can tell any one, Mr. Lincoln, how to go out and put up a building and handle the selection and training of 50 or 100 welders you are doing a lot better than I have found I can do. There is only one way I know of and that is to get out and put the harness on and work right with them. That is what we are doing in the oxy-acetylene industry—going out and standing right behind them, exactly like our boys here in Cleveland are standing by the Illuminating company on this job they are doing.

W. J. Meadowcroft (chairman, Philadelphia Section): I feel that we have a real problem on our hands in connection with welding structural iron. Mr. Lincoln has brought out the point which was brought out very plainly during the war in regard to welding ships.

I suggested to a general manager of a ship building company that they change the design of the ship, the same as in the plant in which I am working did in order to construct a body so it could be welded. The general manager was perfectly satisfied they were making money and paying dividends with the present construction and he didn't seem to be at all interested in welding at that time. I asked him if he didn't expect some day to have competition.

He said: "When competition comes, we will meet it."

It seems to me that in the structural iron game there are many millions involved, and I'd like to make a suggestion regarding the start of welding on a large scale on structural iron, and that is this: Can't we start on various sections of the building to design and construct those particular parts so that various methods of welding can be applied and then work on the balance of the structure?

It means such a great departure to simply start an entire build-

ing, where many, many millions of dollars are involved, and simply tell the contractor, architect, etc., they must change the entire construction.

W. Spraragen (American Bureau of Welding): I agree with the gentleman who said we ought to have data. I don't care whether Mr. Carter goes out to Texas and does the job. Unless he takes down accurate data, cost figures, knows how it is done, he will have to do the same thing over again when it is done out in Oklahoma, say. Another thing, Mr. Carter says to design structures for welding, etc. How is he going to do that? He certainly must have some test figures or else he might call for pipe sections that are twice as large as they ought to be, and the cost may be one and a half times as much as it should be.

I think structures should be designed for welding. I think it is absolutely necessary to have test data; record every job we put up and every test we make—record them so it is available to everybody. A closed door always keeps out more than it keeps in.

Mr. Carter: All you have to do is to go to the National Tube book of standards to find out the strength of a member, and every engineer building a building designs accordingly, and therefore you make your design according to the proper balance of your metal that is going to go into your structure. I can make joints in this tubular section that are up to the full strength of the material. What more can be asked? If you can make joints up to the full strength of the material it is a question of design of the structure itself.

Mr. Spraragen: I'd like to ask Mr. Carter if he can definitely say that in vibration the section will have full strength of material?

Mr. Carter: Absolutely. You can use high quality filler rod, such as nickel steel filler, that are stronger than the base metal, and the result of that is that the stresses are all in the base metal itself and you can depend on the weld up to 100 per cent.

We have got one test going today. It is the biggest fatigue test ever made anywhere. We have a rotary lime kiln 125 ft. long with three reversals in stress. It is turning over once every 2 min. and has been in continual operation since the 7th of last December. It was welded according to correct practice, double V welding, nickel steel rod, with no sign of check showing. The stresses there are up around 18,000 or 20,000 lb., which is pretty high, everything considered.

The only way the riveting fellows have been able to make those kilns stand up was to use double bolt construction with three rivets on each side. As I say, these are giving excellent results.

I heard a rather interesting thing about two weeks ago about that kiln, and that was that it was so much easier to line it with fire brick and make a good solid tube of fire brick, so that the turnout was about 15 per cent more products than the other two kilns which are right by the side of it and being fed the same way.

Also, the welded construction has gotten away from a lot of radiating surface on butt straps and rivets. All told, that kiln, although it cost $5,000 more than the kiln right by the side of it, is more economical. Of course, it was the first one that was made.

Mr. Spraragen: Would you be able now, without any further tests, to design a four-story building by pipe sections?

Mr. Carter: Not only I couldn't but I wouldn't want to do it. We are working on smaller buildings. We are working out tests on trusses and things of that kind, which are a part of the work. It is possible that a four-story building might be in line in the next year or two, but I believe in starting on those things we know we can reach.

Now our own company is putting up buildings here and there and we are working right at the present time on the design of a tubular building for our Prest-O-Lite plant. The plant we build next year will probably be built along the lines I am talking. As soon as we get those designs in and all checked through we will have a much bigger floor space which will probably be of tubular construction.

Mr. Finn (Bethlehem Steel Company): Mr. Carter recommends the use of tubular sections for reason of saving weight. Isn't it a fact that savings in that way would be offset by the additional cost?

Mr. Carter: That is a matter I believe for the steel maker rather than the designer. I don't really believe the tubular construction is more expensive than these fabricated special shapes that are made up with several bars and webs and things of that kind that are being used now for columns.

Mr. Burkhart: I wish to take issue with Mr. Carter that it is necessary to go to tubular sections in order to fabricate a building. I think that faster progress will be achieved by using our angle sections, our T's and channels and beam sections as they are now made. It is possible to make welded joints with these sections with full strength of the members. For instance, if you are going to use an angle as a member or as a strut it is possible to attach both legs of that angle to the member that it is to be fastened to and that can be done with attaching one leg itself and by an angle clip to the other leg and all welded together. There shouldn't be any question about the amount of welding to be done in order to make that member carry the full value. We know that the welded material is harder than the parent material, and if it is harder it has greater value in shear than the other metal. Therefore, you can figure the shear and put in enough welded metal to take care of it.

If we follow along that line of using structural material as we find it today, we are going to accomplish more in a shorter time than just to design buildings of pipes when pipes are not ample to use for the construction of the beams, and cannot be used for a great many other members in a building.

President Ewertz: This paper is productive of a great deal of discussion, but unfortunately the time we have at our disposal is not sufficient to permit us to go on much farther. There are quite a number of different phases to this question that an outsider observes from a discussion of this kind. You are going to have many designers of buildings buy many different forms of material, because you have many different minds working on it. To substitute welding of any kind for riveting is fundamentally wrong and should not be advocated by any welder, even though it may seem revolutionary. It is a fact that if you put it up to the engineer himself to devise the way of construction for proper application of welding he will consider that an achievement and take part in it on that account.

I tell you this because I happened to be up in Bethlehem some two or three years ago and talked welding to our drafting department and I just talked fundamentals. When I got through I had more questions asked me, why you could do this and that and the other thing, and it was surprising to me to see how quickly the minds of those engineers were able to apply the fundamentals to the work they were doing.

Ship construction was mentioned here. The first iron ship built was built of plates and plate iron. There was no such thing as angles, T bars, V bars or anything of that kind. The steel people hadn't learned how to do it. There was no welding possible, so they bent some straps of flat iron like a U strap off the flat iron that was set on edge on the plate iron and they riveted two legs of the strap to the shell plate and in that way produced the flat bar reinforcement on edge against the plate.

Now all you have to do is to go back far enough to get to the fundamental idea of what you are trying to do, then start from there and design for your welding. And when a man comes to you and says, "I have a building all designed for riveting, will you weld it for me?" I would say, "No, sir, I will not because it is wrong."

Discussion "Welding as a Method of Fabricating Large Structures," by H. Goldmark (Consulting Engineer), W. Spraragen (Secretary, American Bureau of Welding), and W. L. Warner (Industrial Engineering Department, General Electric Company).

H. L. Whittemore (Bureau of Standards): This matter of welding research—we have done a little of it, and they tell us that parts of steel structures are going to be welded hereafter, really going to be made into one piece, not hitched together with rivets. Of course, rivets were all right for our fathers and grandfathers because they didn't have anything better, but we have got something better now, and that is welding.

Of course, you can get a welded truss that is just as good as a riveted truss with a good deal less waste. When they design your

joint so you get 100 per cent efficiency, I think it is evident you can make a good deal smaller section than you could for a riveted job, and when the designers really get their hands in it looks to me as if they are going to make continuous beams throughout the structure. I think it is perfectly evident you can save a lot of material if you can carry heavy bending movements over the columns. I hope lots of things will be welded in the future. If the fellows here get together and pull together, just weld themselves on the job, I am pretty sure you can get over 95 per cent efficiency.

We tested some tanks, and the efficiency was a good deal more than that, and it is quite evident if you could get 95 per cent efficiency on all the jobs that really could be welded, there would be a big demand for electricity and gas, and lots of fellows living in the world during working hours, at least, would be looking through blue goggles.

When you get these pieces welded, you are not going to have any pieces falling off, not going to have any rattling. That, I understand, is the chief objection to sheet metal carry-alls they put together up here in Detroit. They start in on the shop work and get the pieces out for welding jobs, and it is pretty easy. Of course, I never did it, but it looks easy. If you can get them in the right positions, welding will freeze them that way forever. You don't need to worry about it.

Somebody said, "How are you going to do all that welding on lots of things?" Well, I don't know. I think there are lots of other fellows that don't know, but it is worth while to find out how to do it if it can be done. Lots of work has been successfully done, but I don't believe the structural work for any building like the Woolworth was ever put together all by welding, and you can't expect the welding shops to work it all out cut and try. There are too many involved problems. There are lots of metallurgical problems that enter in welding, and I think we ought to know a good deal more about them.

All this means industrial research, which lots of people say should be avoided at any cost. Satisfactory investigation of welding is going to be expensive, going to take a lot of time, a lot of hard work, but it is the only way to solve the problems and do the thing properly.

In commercial success, as I understand it, the large profits can only be made in one of two ways. One is by using improved methods; the other by exploiting labor and raw materials. It is perfectly evident the first method is the only way you can go at this job.

Industrial research involves risk; however, in this particular case, we are perfectly justified in taking the risk and finding out. I might quote the case of the Queen of Spain. How did she know Columbus was going to discover a new world? She didn't know.

If you want to ask a fellow who has tried industrial research, why don't you ask J. J. Carty, vice-president of the American Telephone & Telegraph Company, and head of their research department which employs 600 engineers and scientists, and costs them $8,000,000 a year? You say that is a lot of money. Maybe it is, but Mr. Carty insists in his recent talks, as you may have read, that he not only made a lot of money for his company, but makes it for all the rest of us. He estimated that if he took just ten of the improvements that were worked out in the laboratory between 1900 and 1920, if the jobs could have been done at all, the cost would have been $500,000,000 more than the actual cost. That comes back to the people that are using telephones. He points out that none of the foreign countries have a telephone system that can hold a candle to ours. Perhaps you have tried to telephone in Germany or some other places in Europe. You might as well go over and talk to your party in the first place. The reason Germany has such a system, he points out, is that they have very insignificant research departments. Maybe it is because they are under Government control.

The quickest and surest way to lower the cost of steel construction is to weld it, and the quickest and safest way to weld it is to find out just how it ought to be done in the laboratory before you do it outside. That will prevent bad welds getting out into service. I think you can depend on Dr. G. K. Burgess, Director of the Bureau of Standards, to help out any way he can. We are always interested in problems of this kind, and if we get the welded structures and lower the cost of construction, we have done our share toward lowering the cost of living, making this world a better place to live in.

L. H. Miller (Sec. Am. Inst. of Steel Construction): I think probably before you start in in the welding business in the structural steel industry you ought to have some kind of an idea of how big a field you have got. At the present time there are approximately 3,000,000 tons of structural steel used in the United States and Canada every year. That doesn't include tanks and agricultural instruments, ships, and things of that sort. It is steel used under stresses.

Every ton of that structural steel has an average of approximately 150 rivets, and they cost somewhere between 10 and 20 cents each, depending on whether you drive them in the shop or in the field. That includes the entire cost.

Now, as far as the engineer being satisfied with the weld is concerned—the engineer does know what a rivet will do; he knows positively what a rivet will do. We know, and we want you to help us show the engineer how a weld can be substituted for a rivet satisfactorily. He has got a lot of mental resistance to overcome, and he is justified in it. Every rivet that we drive is under suspicion, and as far as I know there has never been a rivet that failed.

We don't know all there is to know about the welding business; we do know something about the structural steel business. We do know that among other things, that in using your tubular sections in a building of this kind, to obtain increased strength of material you don't get anything but the ordinary built-up column that will carry a building of this kind, which has exactly the same strength, as if it is built up out of angles, or plates, or rolls. The stresses are known, and we know exactly in what direction they act, and how they are distributed from one place to another. We can take plates and angle girders and determine how many rivetings have to go between the web and the flange to develop increased strength between the web and flange. If you can show us how we can persuade the engineer to accept a weld for those things, we want to know it. We want to reduce our costs.

The work that has been presented so far has been dealing largely with welds not under stress. Our business is dealing with structural steel under stress, and we have to know exactly what every rivet carries in shear, how much it carries in bearing, and if it is long we know how much it will stand in bending. We know exactly what the rivet will do, whether you believe it or not; at least we think we do.

The weld can be made, is being made, and if you start it, say on the base plate of the columns—supposing instead of starting in with these roof trusses there is a lot of work to be done in assembling the base of a column to the bearing plate. It could be done properly and economically with a weld. We could save a lot of work in our field if you did it. I know there are places where columns are being welded to base plates, and it is being done successfully. The bearing value of steel is just about double what the compression value is; in fact, steel doesn't have in its absolute literal sense a real compression value. It fails by shear. It will fail by transverse shear. Load a column on its axis and if it is mechanically straight and loaded concentrately it will fail by shearing across somewhere around 35 or 45 degrees, and then it begins to buckle at about that point.

Now, the mental resistance of the engineer knows these things, and he knows you have got to satisfy all of the conditions that will develop them. When we drive a rivet, for instance, we know from tests that the contraction of the rivet after it is driven has developed more friction between those plates than the rivet ever gets in shear. In the case of your welding, instead of pulling your plates together, you are not going to have any of that to work with you. We get enough friction right now between these rivets so that, before we reach the calculated stress in the rivet, it is all carried in friction. This can't be developed at all with the weld; in fact, there may be a possibility of your generating expansion.

Now, in the matter of plate and angle girders, I believe that it should be possible to project a spot weld through a plate girder as a substitute for a rivet if you will develop equipment to do it,

but you have got to satisfy the inspector and the engineer that a weld exists. When he looks at a rivet he has absolute evidence of its being there. When he looks at a projected weld through the plate and angle girder, he has no evidence at all, and if we are to test every piece, every plate, and angle girder for railroad purposes, it is going to cost us more for equipment to test than it is to construct them.

I know that the rims of automobiles are electric welded together, and the process of manufacturing expands the rim into its final dimensions, giving you a test by the process of manufacture. I know there are manufacturers that are riveting up steel joists that test every member before it goes out to destination. But when it comes to the big tonnage of structural steel you have got to have something besides a test, because even if you did test it the engineer would say some of your welds were carrying more than they ought to and the others were not doing anything. He has got to know each one is doing its part. He doesn't believe in taking any chances.

In my office not ten days ago I had a letter from an inspection bureau in the Northwest protesting against the use of a burning torch for any purpose. He said: "If we are going to permit the burning torch in the industry at all, irresponsible people will use it, and it ought to be eliminated." Of course, he doesn't consider the fact that the medical profession has absolutely refused to wipe out narcotics because some people use them harmfully. I don't know of anybody who contemplates a law to do away with automobiles because there are irresponsible drivers. I don't know of anybody that wants to do away with doors because somebody will leave them open and bump their heads.

You have got more mental resistence to overcome to develop the use of the weld than you have in your actual practice. From what I have seen, you need more knowledge of what goes on in the stresses of a structure of a steel frame before you go very much farther with your development. The engineer knows more about what is going on in the form of stresses in the structure than you people do. We have analyzed these stresses, we know where they are; in fact, in some cases we have gone so far as to make photographs of the stresses, and we know which way they are going.

I don't want you to misunderstand me. We are for anything that will reduce the cost of structural steel. The outstanding legs of those angles are not the only ones that work. The leg of an angle against the flange of a girder and leg against the web of a column are just as effective and just as active as the outstanding flange is in every case. You have got to conceive it. It does just as much work.

I believe the human mind is just about the narrowest thing that has ever been invented. Tradition and prejudice operate in more contracted areas than anything I know of. I think you can see that right in the medical profession. The medical profession are absolutely intolerant of each other. They have divided themselves into certain schools, and the other fellows are all crooks, every one of

them; they can prove it. And I can see that all the way through every scientific profession. It has got the same attitude toward things, and you must consider you have got to deal with that mental resistance, and it is more of an obstruction than your developing these other things, because we can show you how to figure these stresses if you will show us how to make the weld.

If you can devise in your welding processes something in the form of a visible evidence so that the engineer or inspector can see it, you will get somewhere. Spot welding has got to be combined with your other work if you are going into the big structural work. If you are going into big work you have got to combine it, and if you can assemble three or four thicknesses of metal together, get them between your spot welding equipment and leave on the outside of that specimen something the inspector can see as evidence of a weld, you have answered his question.

Now, in the process of heating an ordinary rivet with an electric heating equipment, the heat is developed, as I understand it, at the center of the rivet first, and at the end of it last, that is, the most heat is developed where the greatest resistance is, and if you could put on the outside of these plate girders two rivet heads and have those rivet heads of such a composition that they would not weld fast to the outside until all the inside parts had been welded, then the man has some evidence of a weld having been completed. It doesn't necessarily have to be a rivet, it could be a small disk. I don't know whether it would work or not; it may not work in that process, but that might be experimented with. The real point is, he has to see something or he won't believe it. I don't know whether I would or not. I don't know whether you would if it weren't for your job.

I think the industries of the United States are spending something in the neighborhood of $30,000,000 a year in research work, and I think we can accomplish an enormous amount if we will cooperate with each other, but when you go to the engineer to tell him how to make welds, be willing, and be prepared to tell him what your weld will do, and know what the stresses are you are going to tell him you can take care of.

Mr. Spraragen: I wouldn't have Mr. Miller believe that we know all about this work and that we are ready to pitch in and design structures. About three years ago Professor Adams, the Director of the American Bureau of Welding, Mr. Hobart, Mr. Ewertz, and some of the rest of us felt this was a wonderful field for welding, but we felt the time was not ripe for it, and we waited a year. It wasn't time even then, although we made an effort to extend the use of welding for vessels, oil tanks, rail joints, and things like that with remarkable success.

We now feel that we are just about ready to start in the structural field, and that is why this program was arranged as it was. We are not ready to weld structural parts; we are ready to try to find out how to do it. The American Bureau of Welding, which

is the research department of the American Welding Society, and is also closely affiliated with the National Research Council, hopes within the next two years to undertake a $200,000 investigation to find out how to weld structures. We know we are never going to do it unless we are able to get the assistance of men like Mr. Miller, Mr. Edwards, of the American Bridge Company, and others. We think we know something about welding, but we don't know anything about structural work, and we have got to have their help, have got to work with them in committees, got to fight with them, and in the end lay out a program for investigational work and tests that will answer the questions, and then we will know how to design simpler structures and build from that to the larger work.

C. J. Holslag (Electric Arc Cutting & Welding Co.): Mr. Chairman, we have a favorite test to try to convince small structural men. We have them rivet two pieces together just as good as they can, and we run a weld down each side just as Mr. Warner's diagram showed, and in every case upon pulling the rivets loosened. If that doesn't show the weld holds the plates tighter together than the rivets, I'd like to have it pointed out.

Mr. Miller: The Bureau of Standards made some eighty or ninety tests along that line, and the first drop of the beam in testing machines will show where friction is overcome and the rivet comes into its full action, and almost without exception that rivet doesn't come into action as a rivet until after it has passed the calculated stresses.

Mr. Candy (Westingouse Electric & Mfg. Co.): There is one point I want to raise. A little while ago in discussing the design of that particular truss, there was the question of shearing the necessary angles to just the exact length to make butt joints instead of lap joints. It just struck me that in forming up these members in the average shop, the way they are sheared off, the accuracy with which they are sheared will probably require an eighth of an inch or a quarter of an inch leeway, and in order to get the pieces sheared with sufficient accuracy, to have them fit in nicely with butt tacked joints for welding, it might increase the cost considerably over what it would be through using the lap method. Certainly, it would run up the cost considerably to cut away part of a leg of an angle and allow the other leg to extend over the joint member, if I got the idea correctly there.

With reference to what Mr. Miller had to say about the use of welding and structural steel work, it struck me that so far, apparently, the whole effort has been to get a design that will replace the rivet, and according to statements rivets do not fail in structural steel work at the present time. Therefore, the structure must fail at some other point, and why should we make our welding designs based on what the rivet will do when it isn't the rivet that is failing?

The question of being able to give the operator some indicating button or something in the weld which will show to him when he

has a real weld; in the case of spot welding, for example, putting a button on the outside, or whatever it may be, I couldn't help but think of a great many cases where the rivet holes do not line up, and it is necessary to use a drift pin and ream out the hole. In that case the rivet is driven up, and it is desirable, as I understand it, to have the rivet fill the hole. I don't know what sort of device the riveter has to tell when the hole is filled, but it might possibly be adopted in welding to show when the welding fills it.

With reference to the gentleman out West who doesn't want to permit the use of a cutting torch on the premises, the thought came to me that is almost a hopeless case. I think some of us ought to get acquainted with his son, if he has one, and work on him for the coming generation.

President Ewertz: I just want to throw in a suggestion. Mr. Miller states rivets never fail. That isn't quite true. I know cases where rivets have failed; but don't forget a structural engineer allows a margin of safety from 4 to 6 in all his work the same as every engineer does in his work. If that wasn't true we'd have an awful lot of failures in all lines of activity. But if you have a piece of metal good for 40,000 and only put 10,000 pounds on it, it naturally will hold up. In designing machinery when we put stresses on a 60,000 member down to 6,000, you certainly are allowing all kinds of margin of safety to protect the general public. If the design of welding is as strong as the riveted joint with the same strength, you have got a margin of safety of at least 4. In an automobile you have a margin of safety of about 2; in an aeroplane you have damn little margin of safety, and the consequences of these different degrees of safety are evident by what happened to our different machinery in use.

Mr. J. Edwards (American Bridge Co.): I came here on an invitation in hopes of learning something about welding; I have learned more or less, but the main thing that I have been impressed with is the optimism of the people who are advocating welding. I think that is what you all need in order to put this process across. I am very glad to see that you have it.

But, on the other hand, I noticed there is an awful lot you don't know about structures themselves. I gathered this from the talk I have heard, and, as Mr. Spraragen has said, the way to arrive at what we are after is by cooperation.

Some five years ago our people became interested in this subject. We tried to keep in touch and keep posted. We have done more or less investigating; tests that were referred to in one of the papers were made by our people. We made numerous samples of the riveted members under different conditions as we thought they would exist. We also had similar members spot welded.

I notice all the discussion so far has been on what we call strip welding, but naturally a man leans toward something that is very near the practice which he has been brought up with. We have

satisfied ourselves that you can make a spot weld that is as good or better than a rivet.

Now, the problem we are considering, and what we are interested in, and you people have got to show us is, can you perform the whole process from the raw material to the finished structure as cheaply as we can do it under present systems? There is a saving in material; I want to bring that out, but you save material only in your tension member. There is no saving in the compression.

It may be you won't save so much even in tension as you think you are going to, but as the official representative of the American Bridge Company I want to tell you we are interested. That is the reason I came here. We are willing to cooperate with you. We want, if it is possible, to more economically build structures. We want to adopt that method. It will have to be slow, have to be tried out. We are "from Missouri," we will have to be shown.

I want to call Mr. Spraragen's attention to one thing he has left out of his paper, and it is the most important, as far as we are concerned. He has left out the process of manufacture of the preparation of the material to be welded and erected. There is an awful lot of work to be done between those two items, and further on in his paper he has given us on page 54 "Needed Data." There are five numbered items there, and if you will help us answer those five we will go a long ways with you toward solving your problem.

President Ewertz: We appreciate that, Mr. Edwards. I can somewhat sympathize with you, though I am a very ardent believer in welding, because I used to be a ship builder and I have had difficulties similar with what you are dealing with.

Our president wrote me a letter just before I came up here, saying, "We are with you, Ewertz; we stand back of you, and we expect a lot from it." Bethlehem is very much like the American Bridge Company, looking forward—to what's new, what's useful!

Discussion of paper on "Use of Spot Welding in the Structural Field" by H. A. Woofter, Electrical Engineer, Thomson Electric Welding Company.

Mr. Wilson (Linde Air Products Co.): I'd like to ask Mr. Woofter if there is any special preparation made on the structural members at the spot where they are going to be spot welded to take care of any rust, slag, or impurities which might be on the surface which would undoubtedly enter into the weld, and what effect those impurities would have on it?

Mr. Woofter: That is a point that is very well taken. Rust or oxide of iron is a very complete insulator, and by putting two rusty pieces together you will not get any weld at all. It is completely insulated, and current does not pass through. Paint, especially red lead, is a complete insulator for such low voltages as five of six or seven volts as is used in spot welding, and if there is any paint on the beam it should be removed before making the spot weld at that particular point.

As regards impurities in the metal, anything like galvanizing or something of that kind is volatilized and thrown out similar to the waves in the water when you drop a pebble in.

R. D. Reed (General Electric Co.): I'd like to ask Mr. Woofter if it would be possible to spot weld three sections together?

Mr. Woofter: That is extremely easy; in fact, it is easier to weld four pieces together than two or three. The reason is very apparent. You are heating at the spot, and you can do the same weld with a smaller machine, provided you have sufficient mechanical pressure.

President Ewertz: I'd like to hear from Mr. Edwards on this paper.

Mr. Edwards: I didn't realize when I arose last time that we were to have this spot welding paper, or I would have deferred my remarks until then. There is very little I can add. I can answer the question, I think, probably more truthfully than Mr. Woofter did about the preparation of the material. That was something we were very much interested in, because it was a matter of cost. We were a little bit suspicious we'd have to pickle that material to remove the scale. Some of the material was taken from stock, and the balance of it came direct from the rolling mill. The material that came direct from the rolling mill, as far as I know, wasn't touched. There were a few plates there that had been laying in stock and were rusty, and they, too, were used and a wire brush was run over them—no other preparation—to remove the oxide from the surface. The cost of that was practically nothing, provided we got fresh material from the mill.

There is one thing I neglected to say, and that is that structural engineers who have given any study to this matter realize that the present structural shapes are not what they should be for the welding process. Don't think for a minute they are asleep on that subject, but in order to get anywhere with your process you have got to creep before you run, and you have got to make use of the standard commercial product of today, see what you can do with that and then as the process proves itself efficient and economical and worthy, new shapes will develop, new methods of detailing, the same as has been developed in all other lines of mechanical and commercial products. We are only traveling in a circle.

Some years ago (I am not the youngest man in the crowd) I started detailing buildings and structures when we used to chase every fire in order to get a steel truss substituted for a wooden one. Naturally, steel trusses were built with their members running at the same angles and placed the same way as the wooden ones, and they had wooden members and wrought iron rods with cast iron washers. Even at that time the wrought iron trusses that were in existence, the earlier types that were put up in this country, were welded. I have seen a great many trusses on brick walls covering gas houses where they found out they'd have to have something which was fireproof and perhaps a little bit more lasting than the

old wooden material, and they were made out of square bars, not tubes, with welded joints, and I have seen them 6½ in. apart welded to the top of the rafters.

Maybe we are traveling around in a circle and we will get to complete welded structures within limits—I don't expect we will ever build a bridge across the Hudson River with it, but we are going to build our smaller structures, to my mind, particularly where there is large duplication where you can make joints in the shop and hold your material while you weld it. It is doing to be done, and it is going to be done in the very near future, but as I pointed out, there is a wide gap that you have got to bridge until the structural men will use it between the time you cut your materials and run it out. It isn't simple. The comparison of the cost of punching holes and driving rivets interests the structural man with the comparison of making the spot weld or the strip weld, and also all the other things that have to be done in that space in order to finish your product.

Mr. Candy: Mr. Chairman, several years ago our company was approached by one of the concerns making spot welding apparatus and we had them make a number of tests for us using, as I recall, two ⅜-in. plates to be spot welded together. I took a number of those samples back to East Pittsburgh with me and we cut them through and had them polished. The specimens looked very fine, looked fine even before we polished them and after we polished them they looked even better.

Upon dipping them in a 10 per cent solution of nitric acid we discovered the section through the spot where the current would pass through had a decided appearance of a cast structure with the lines of the crystals directly through the plates.

I understood Mr. Woofter to say the spot welds are in the nature of forgings, and therefore, I'd like to know what was wrong when they did this work.

Mr. Woofter: About five years ago we commenced a very rigid research along the above lines. We realized there was something wrong at that time with the spot weld. We also found the same thing you mentioned. On analysis it was found the old method of spot welding did not give sufficient mechanical pressure to force the molecules together and make a complete cohesion. That has been remedied in the newer types of machines by several manufacturers, and now the metal just at the moment of plasticity is forced together; when the welds are cut and examined it usually shows a much deeper granular structure than the other part of the metal.

Program of Second Phase of Investigations of Welded Rail Joint Committee

Object: To improve present methods of making seam welded joints.

Investigation No. 1

Object: To develop a joint plate and methods of welding which will give the maximum area of welded cross section in seams; particularly top seams.

General: In this investigation for the preliminary work it will not be necessary to make full size joint specimens as two kinds of values, namely area of soundly fused weld metal and shearing strength of the seams will be obtained as indicated below. Specimens will be made by welding up 12 in. sections of fish plates in a 60 ft. Association Standard 7 in. girder rail. The distance between sections shall be at least 3 in. The length of a welded seam shall be 10 in. (1 in. space being left at each end). Both top and bottom seams on head and lip side shall be welded. The welding shall be done in such a manner as to simulate track conditions, which means that the rail must rest on the floor and not be placed on a bench, as it is the object of this investigation to check the difficulties which the operator must encounter with a particular type of fish plate and method of welding.

These test specimens shall be cut apart by an oxy-acetylene torch. Each section having a 12 in. fish plate welded by 10 in. seams shall be cut in half with a saw and an examination made of the face to indicate quality of welding. One half of the section shall be sheared by placing them in a compression machine and the force necessary to do this recorded. The other half shall be wedged off by means of a triangular wedge after a kerf has been made through the center of the fish plate by an oxy-acetylene torch. On the section that is wedged off a careful record shall be made of the cross sectional area of soundly fused metal. Three specimens shall be made of each variable.

One wire shall be used throughout this investigation. Full size photos shall be made after deep etching of each specimen.

Variables: Several selected types of fish plates shall be used. On each type there shall be employed the following methods:

a. Hand feed with a 9/32 in. rod in one layer depositing 1½ in. of rod per inch of seam.
b. Hand feed with 9/32 in. rod depositing 3 in. of rod per inch of seam.
c. Hand feed with 9/32 in. rod depositing weld in two layers using 1½ in. of rod per inch for each layer.
d. One 9/32 in. rod in position.
e. One 9/32 in. rod in position and rewelded with another 9/32 in. rod laid in position on top of first weld.

f. Repeat "e" using third rod.
g. Metallic arc weld with 5/32 in. rod one layer same cross section as in "a."
h. Metallic arc weld with 5/32 in. rod one layer having same cross section as "b."
i. Metallic arc weld with 5/32 in. rod metal deposited in two layers each having same cross section as "c."
j. Metallic arc welding using ¼ in. rod depositing same amount of metal as "b."

Note: The three best types of joints from the above test will be checked by full size specimens in tension and repeated impact (three each). These full size specimens shall be preheated before welding. No pressure shall be used in bringing rail heads together. Twenty-six inch joint plates shall be used for check tests. (Types of fish plates to be suggested by members of Committee.)

Investigation No. 2

Object: To test several kinds of welding wire—Roebling, Rail Welding and Bonding Co.'s No. 200, Armco and Bethlehem. (carbon and metal arc).

General: For each of the wires tested the following methods shall be used:

1. Weld together two plates of 0.20 carbon each 9 x 16 x ½-in. Plates should be double beveled to a total opening of 90 deg. each side and welding started with 1/8-in. opening at center at one end and 1/6th of an inch at the other end (usual allowance for contraction during welding—1/8-in. per foot of seam). The metal is to be deposited in one layer each side and welding to be done in flat position. In making the 2nd weld it should be started at end where welding was just finished and not started at the cold end. From each of these plates there will be cut three tensile and three bend test specimens in accordance with American Bureau of Welding Specifications Bulletin No. 1.
2. Repeat above with plates preheated.
3. Repeat (1) with plates having 0.75 carbon.
4. Repeat (2) with plates having 0.75 carbon.

Note: Check two best wires using full size specimens (preheated) with best joint plates and method of welding as developed by investigation No. 1. Three joints each shall be made for tensile and repeated impact tests.

Investigation No. 3

Object: To compare the value of preheating, postheating.

General: Nine full size specimens (three each for drop, tensile and repeated impact) shall be made of each variable given below with best wire and joint plates developed by investigations 1 and 2.

Variables: (1) Make nine specimens without preheating or annealing, (2) Repeat 1. preheated, (3) Repeat 1. postheated.

Note: Actually three specimens only have to be welded under Part 2 for drop tests, as the results of the check tests on full size specimens used in Investigation No. 2 can be used for repeated impact and tensile tests.

Investigation No. 4

Object: To test the value of base plates. (⅜-in. plain plate 9-in. wide).

General: Six full size specimens shall be made of each variable below with best wire and joint plates developed by investigations 1 and 2.

Variables: 1. Base plates not preheated.
2. Repeat (1) preheated.

Investigation No. 5

Object: To compare the merits of the different methods used in securing tight fit between rail heads.

General: Six full size specimens shall be made of each type with best wire and joint plates developed by Investigations 1 and 2. All joints shall be preheated.

Note: Types to be suggested by members of Committee.

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Reclaiming Worn and Broken Parts of Machinery*

T. T. COPELAND†

When we speak of welding we mean to unite two sections of metals together, to be as strong in the weld, or if possible, stronger than the original section. The metals commercially used are steel, cast steel, cast iron, copper, brass, aluminum, etc. Of these metals, steel, cast steel and cast iron are most commonly used, hence the welding of these metals is of great importance. Before making any claims for welding let us ask ourselves a few questions pertaining to the maintenance and safety operation of the equipment we intend to use.

It is an understood fact that oxygen and the different gases used are of a highly explosive nature, and it is of the greatest importance to know how they should be handled.

Where you have a generator set in producing your acetylene gas, do you frequently wash out the generator and make a thorough inspection for corrosion and pitting, due to water and acid reaction?

Do you examine the mechanism to see that it is working properly, that too much carbide will not discharge into the water, and create an over-supply of gas?

Do you examine and test safety valves?

Do you examine the pipes, manifolds and valve connections for leaks?

Do you have a flash back between the generator and manifold in case of an explosion in the torch or hose which may travel back through the line into the generator?

Do you make an inspection of the hose and connections for leaks?

Do you have copper tags on end of hose next to regulator marked GAS—AIR to distinguish the difference between oxygen hose and acetylene hose, which will cause an explosion should you get them coupled up wrong?

Do you test your regulators for leaks before using, and do you make the test each time you couple the regulator to a full tank?

I believe the following is a good practice to follow:

First: Open the main valve of the tank, to make sure that no dirt may have accumulated in the valve or opening, which would otherwise go into the regulator and finally into the torch. Then attach regulator to tank making sure that all tension is off of the diaphragm spring, by turning the adjusting screw to the left, disconnect the hose from the regulator; slowly open the valve of the tank and if any air or gas, as the case may be, escapes from the

*Presented at the Nov., 1924 meeting, Pittsburgh Section of the A. W. S.
†Road Foreman of Engines, Carnegie Steel Co.

hose connection of the regulator, it will indicate that the valve seat of the regulator is defective and should be repaired before being put into service. This test should be made each time the regulator is attached to a full tank of oxygen or acetylene.

There is much less danger with the electric welding equipment other than protecting the eyes and body from the violet rays produced by the arc. Thermit welding is practically safe but great care must be used to see that the crucible is thoroughly dry, and that no water should be near when making a weld, in case of an overflow of slag from the weld.

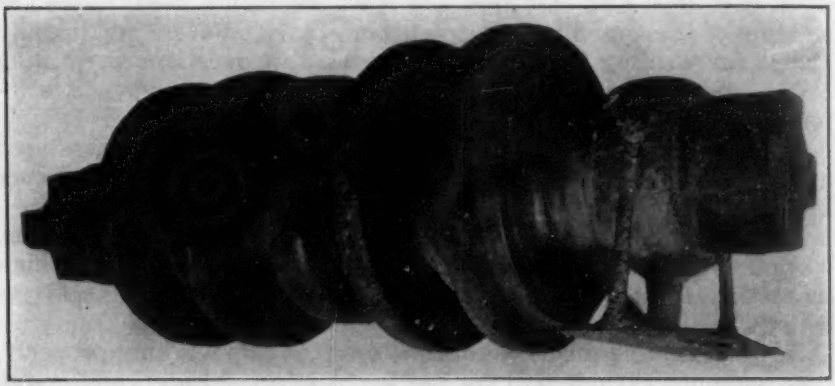

Fig. 1.—Steel roll with wobler end cast in foundry and Thermit welded to roll neck

In recent years there has come to the front three general classifications of welding, the gas, thermit, and the electric arc (carbon and metallic arc) methods.

Each has its own field, and should be used with discrimination to obtain the best results.

I refer more particularly to the man by whom the weld is to be made.

He should be able to advise the proper method to use in order to make the most economical and strongest weld for the service it has to perform, whether it be electric, acetylene or thermit.

Too much emphasis cannot be placed on these facts. For illustration, if a camshaft used in heavy shear duty was worn a half-inch undersize on the cam, and it was necessary to bring it back to its original size, the welder would not recommend the acetylene or thermit process, for it can be readily seen that by the electric metallic arc process it can be done more rapidly and cheaper, and, on the other hand, where a weld is to be made requiring 150 to 300 lb. of metal, you would not use the electric or acetylene gas method, but would advise using the thermit process.

Again: You are confronted with a cast iron pressure cylinder that is cracked or possibly a flange broken, you would immediately say, all that is necessary is to pre-heat and use the acetylene method.

The point I want to make clear is, that the man who supervises the work, or the man who actually does the welding, must be able to say what method of welding should be used in order to obtain the most efficient weld which will give the service required.

It is also important for the welder to have some knowledge of the different materials to be welded, as to what service they performed previous to being worn or broken, as the case may be.

For example, in a broken gear wheel or other parts of machinery —was the fracture caused by accident, overload, improper design for use intended, defects in casting, or strain set up by improper

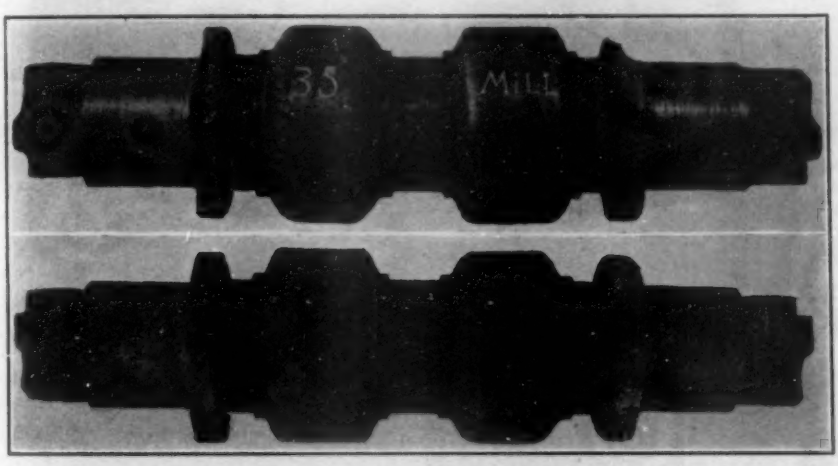

Fig. 2.—Upper figure—Broken 35-in. mill roll. Lower figure—Same roll repaired by arc welding

annealing at foundry? If a cylinder, what pressure is it subject to? The welder operator who is alert will study these conditions before making the necessary weld.

Different Grades of Welding Wire

In order that we may determine a good grade of welding wire to obtain the best results, it is recognized that the most careful consideration must be given to physical as well as to chemical characteristics of the welding wire.

Carbon

The effect of carbon with respect to its influence upon the strength and ductility of natural cooled steel, and the average results obtained by four eminent investigators show that for each 0.1 per cent carbon added to steel up to 0.90 per cent, these properties are affected approximately as follows:

Yield point is raised 3987 lbs. per square inch.
Maximum stress is raised 9363 lbs. per square inch.
Elongation is reduced 4.33 per cent.
Reduction of area is reduced 7.27 per cent.

Manganese

It is a well-known fact that manganese adds somewhat to the tensile strength. This beneficial effect depends upon the carbon content as well as that of manganese.

According to H. H. Campbell (published by McGraw-Hill Book Co.), the effect of manganese upon the tensile strength of steel, each increase of 0.01 per cent manganese above 0.30 or 0.40 per

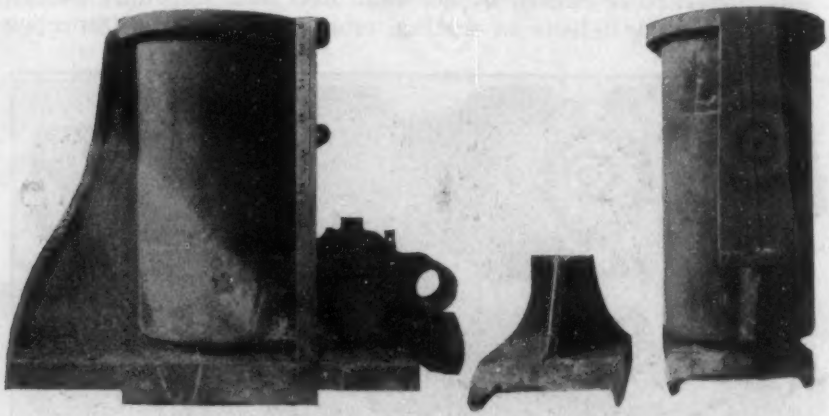

Fig. 3.—Right: Broken steel hammer cylinder. Left: Cylinder repaired by welding

cent raises the tensile strength of steel with carbon content of 0.05 to 0.40 carbon, from 110 to 250 lb.

Nickel

Nickel is used in steel for its beneficial effect upon the physical properties of the steel, for which purpose it is preeminently a strength-giving element. For each 1 per cent of nickel added above 2 per cent and up to 4 per cent, an increase of approximately 6000 lb. in the tensile strength of this steel over the carbon steel is noted.

Phosphorus and Sulphur are Impurities

A report on Cast Iron of the Electric Arc. Gas and Thermit Welding research committees of the American Bureau of Welding, on Silicon, Sulphur and Phosphorus reads as follows:

Silicon reduces the solubility of carbon in molten iron. The most important effect of silicon from the standpoint of welding is that it increases the proportion of free, to combined carbon, thereby making the metal soft and machinable. While the presence of silicon may not directly affect the welding of cast iron it is of great importance since its introduction in the weld has a strong, softening influence.

Silicon also helps to eliminate oxides, promote fluidity, and decreases shrinkages and chilling effects.

Sulphur exerts a very bad effect on cast iron and should be kept

at a minimum. It causes the carbon to be held in the combined state. This increases the hardness and also the shrinkage, since carbon in the combined form occupies less bulk than graphite.

Phosphorus lowers the melting point of cast iron and makes it hard, brittle and weak. The amount of phosphorus is usually kept as low as possible, except in castings having a very thin section. Where a fluid iron is necessary to insure filling all parts of the mold, a high phosphorus iron is used because of its fluidity, in spite of its weakness and brittleness.

Fig. 4.—Lower figure: Copper twiers before welding. Upper figure: Castings repaired by welding

If this be true, it is of great importance that the physical and chemical characteristics be given careful consideration.

To determine the grade of wire for use in electric metallic arc welding where tensile strength is of importance, a test was made using 5/32 in. bare wire with the following analysis: Carbon, 0.36; manganese, 1.03; sulphur, 0.043; phosphorus, 0.016.

Tests

A piece of boiler-plate having a tensile strength of 55,000 to 65,000 lb. per square inch was Veed on both sides and the edges separated ⅛ in. and welded to ⅛ in. reinforcement. The plates were then cut into sections ½ in. x 2 in. x 24 in., with an approximate area of 1.124 sq. in., having an ultimate strength ranging from 63,190 to 65,600 lb. per square inch, and 27.5 per cent to 31

per cent elongation in 4 inches. All reinforced tests broke outside of the welds.

A similar test was made where all the test plates were machined to exact size, ½ in. x 2 in. x 24 in., giving an area of 1.008 sq. in., with an ultimate strength ranging from 60,910 to 61,800 lb. per square inch, and 13 per cent to 34.5 per cent elongation in 4 inches. Four of these tests broke outside of the weld, and two broke in the weld, which was not properly fused along the side of the Vee.

A bending test was then made. The reinforced piece was bent double, or 180 deg., and a fracture developed outside, and near the weld. The machined test piece fractured inside the edge of the weld and through the original metal at about 150 degrees. Out of a total of 18 tests made, three broke in the weld.

A similar test was made using 5/32 in. flux coated wire with the following composition: Carbon, 0.08; manganese, 0.15; sulphur, 0.036; phosphorus, 0.010. Out of the nine tests made on the reinforced welds ranging in ultimate strength from 57,220 to 63,420 lb. per square inch, and with elongation of 4 per cent to 20 per cent in 4 inches, six broke in the weld, three broke outside of the weld. One showed no load in the testing machine.

Out of a total of 18 tests made, 15 broke in the weld.

None of these welds stood a bending test of any importance.

Building Up Worn Parts

In the matter of building up worn parts where machining is not necessary, some experiments were made using ferromanganese, known as 80 per cent manganese, which contains approximately 80 per cent of manganese, 6 per cent carbon, 14 per cent iron and a trace of silicon. The ferromanganese was crushed to granular form and an acetylene weld, by building up, was made on cast iron. After the metal became fluid, using the ordinary filling rod, the ferromanganese was added by sprinkling over the surface of the weld, then puddling the metal with the filling rod to make it uniform. Three drilling tests were made at different points, showing the following analysis:

1. Carbon, 3.48; manganese, 1.90
2. Carbon, 3.48; manganese, 2.40
3. Carbon, 3.48; manganese, 2.10

A similar test was made on steel, using the metallic arc process with 5/32 in. bare iron wire and 140 to 160 amp. The metal was cleaned and the ferromanganese was sprinkled in line where the metal was deposited and each layer of metal was put on as uniform as possible, the operator using a circular motion to avoid small craters in the welded metal. It was readily kept free from scale by using a stiff wire brush.

This was repeated until sufficient metal was deposited.

Four drilling tests were made at different points to determine the composition, which is as follows:

1. Carbon, .58; manganese, 5.60
2. Carbon, .64; manganese, 6.10
3. Carbon, .90; manganese, 9.10
4. Carbon, .75; manganese, 7.60

An actual service test was then made. It happened that on a large steel roll the bottom part of the pass was undersize and it was necessary to build up this pass to increase the diameter ½ in. The entire roll was kept warm during the progress by natural gas flame. Equal parts of 99 per cent nickel and ferromanganese were used in granular form. The method was used as described above and ex-

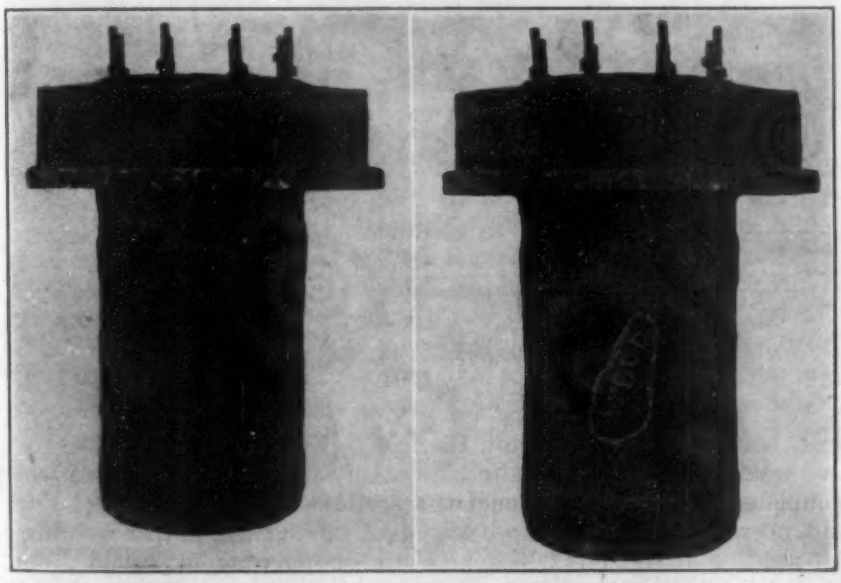

Fig. 5.—Left: Pressure cylinder before welding. Right: Cylinder repaired by electric arc welding

ceptional care was taken as it meant considerable loss if the welding was not done successfully. It was necessary to build up the pass the entire diameter of the roll, hence the analysis should be uniform. In order to accomplish this it was necessary to take drillings at equal points to determine the composition of the metal. This was done as each layer was deposited until the welding was completed, and the final analysis showed as follows:

1. Carbon, 0.21; manganese, 1.33; nickel, 3.77
2. Carbon, 0.12; manganese, 0.70; nickel, 3.21
3. Carbon, 0.14; manganese, 0.98; nickel, 4.91
4. Carbon, 0.14; manganese, 0.75; nickel, 3.77

This composition proved very successful, although there was some

difficulty in machining, on account of hard spots, no doubt due to the high manganese. The roll was placed in service December, 1921, and no further trouble developed. This is no doubt convincing that the physical as well as the chemical characteristics of welding material forms a very important part in welding steel and iron.

Pipe Welding

We welded a 21-in. O. D. steam line to carry 150 lb. pressure having a total length of 1100 ft., with approximately 112 welds. The pipe was in 20-ft. sections and beveled on both ends. Two and three 20-ft. sections were lined up at a time in the shop with ¼ in.

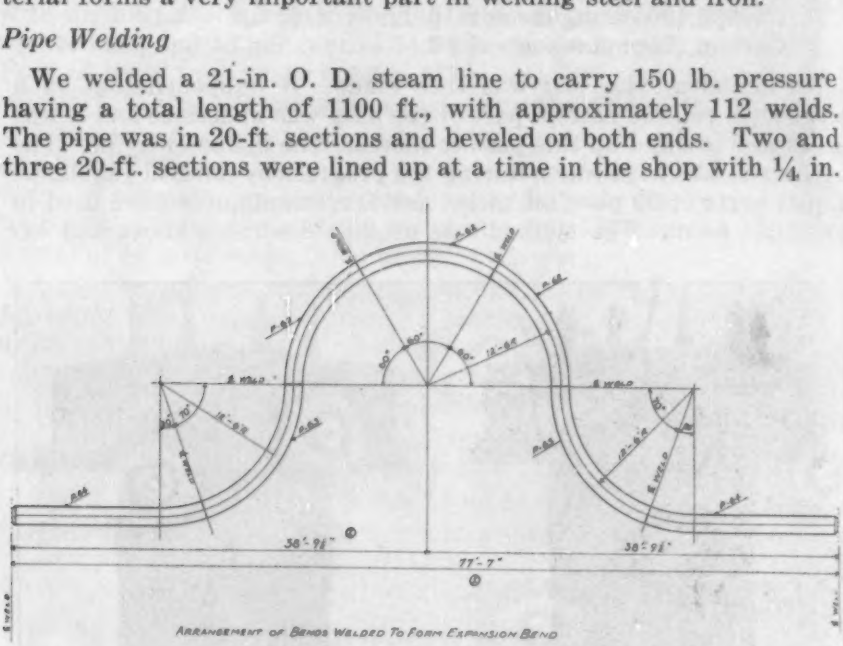

Fig. 6

open between each joint, and then tacked at four equal points by two welders working opposite each other, after which the weld was completed. This method held the sections almost in perfect line and prevented warping, and was used during the entire welding. All welding of sections was done in the shop as far as possible, and then delivered to the field to be lined up, then welded.

By first welding the pipes into 40-ft. and 60-ft. sections at the shop it helped to expedite the work, as a weld in the shop could be done much faster than could be done in the field, due to scaffold work and the handling of the welding equipment. Three expansion bends of 12 ft. 6 in. radius were used to take care of the expansion, equal to 4 in. per 100 ft. at 150 lb. steam pressure, or approximately 15 in. for each expansion bend.

This required approximately 112 welds, of which 74 were made in the shop and 39 were made in the field, consuming 159 tanks of oxygen, 143 tanks of acetylene and 1275 lb. of Norway iron, or an average of

1.43 tanks of oxygen per weld
1.28 tanks of acetylene per weld
11.4 lb. of wire per weld.

Preparation for Welding

It is necessary for successful work to prepare cracked or broken parts so they can be thoroughly welded. The angle of the Vee is very important and should be of such a degree as to be able to get proper fusion at the bottom. In steel plate welding such as used in fire boxes where it can only be Veed on one side I find it a very good practice to have a $\frac{1}{8}$-in. opening at the bottom. In fact, where the metal is to be welded from both sides it is the proper thing to do, as this allows the metal to go all the way through. This applies more to steel plates and cast steel. In cast iron the metal being more fluid makes it more difficult for the operator.

While the Vee should be of sufficient angle to insure thorough fusing at the bottom, by allowing 3/16 in. to $\frac{1}{4}$ in. shoulder at the bottom, it gives the operator a better opportunity to hold the metal and still have the weld extend through the base metal.

Preheating and Annealing

Preheating and annealing are of great importance when welding articles such as cast iron having no elongation, and where machining is necessary.

It is to be remembered that while the temperature of oxy-acetylene is very high, the quantity of heat delivered in a given time is small. It is out of the question to use oxy-acetylene flame for preheating as it is much more expensive than other methods, such as natural gas or charcoal.

In general, the purpose of annealing may involve any one or all of the following aims: To soften the metal in order that it may meet certain physical requirements, or be more easily machined, and to relieve internal stress and strains induced by welding, or by non-uniform contraction in cooling.

Finally:

That welding by carbon or metallic arc, oxy-acetylene or thermit is no longer an experiment but a reality, and used extensively all over the country today, and when the operator becomes efficient in applying these different methods, the reclaiming of steel, cast steel, and cast iron will be a success.

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Welding Rods and Wires

LEKTROX SWEDOX	NICKOX	CYLKOTE
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GAS CARBOX	MANGANOX	BRAZOX
CASTOX	STEELKOTE	BRONZOX
VANOX	LEKKOTE	MANGANESE BRONZE
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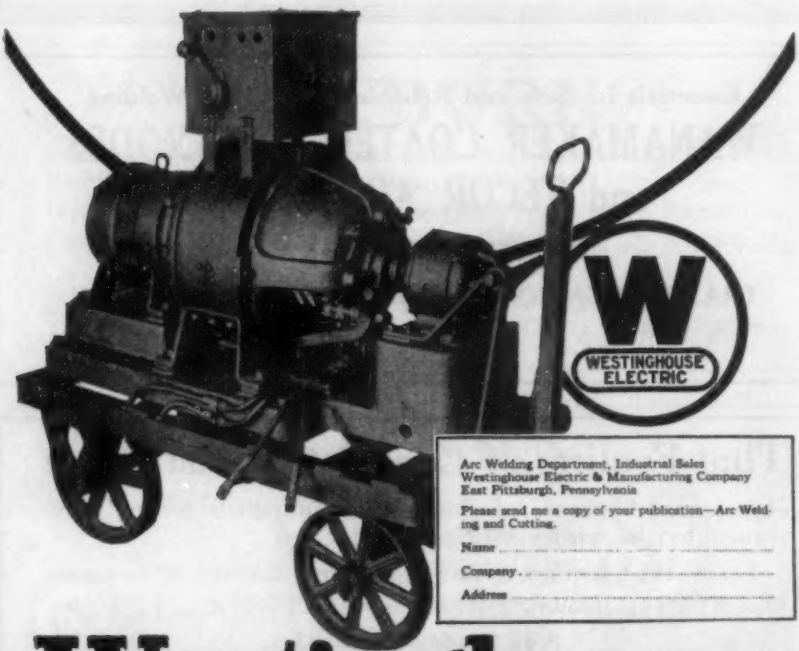

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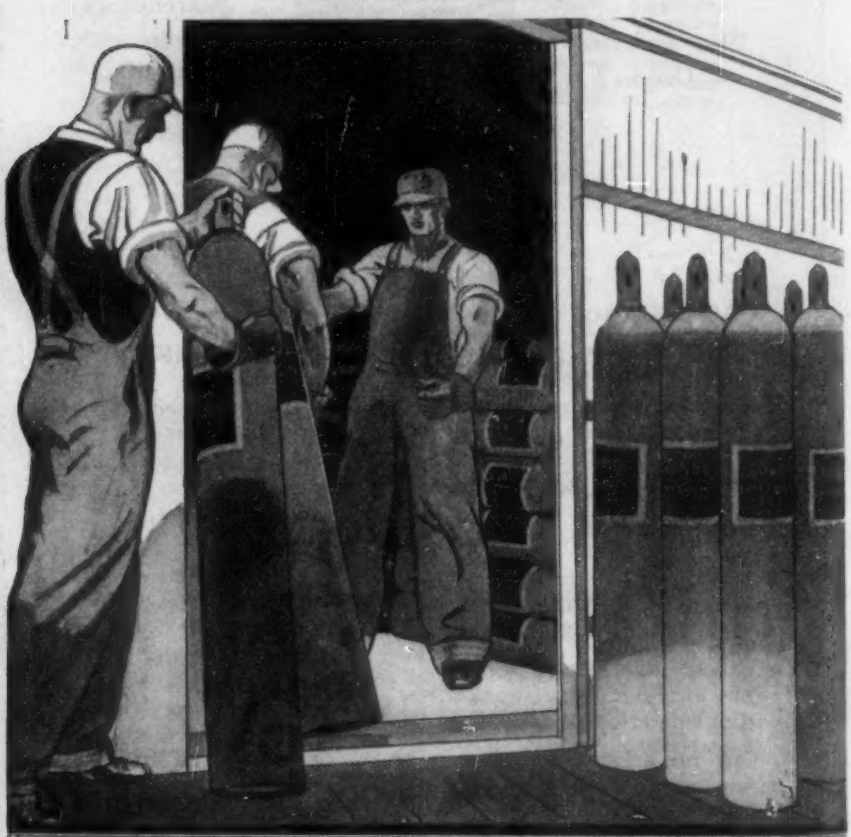

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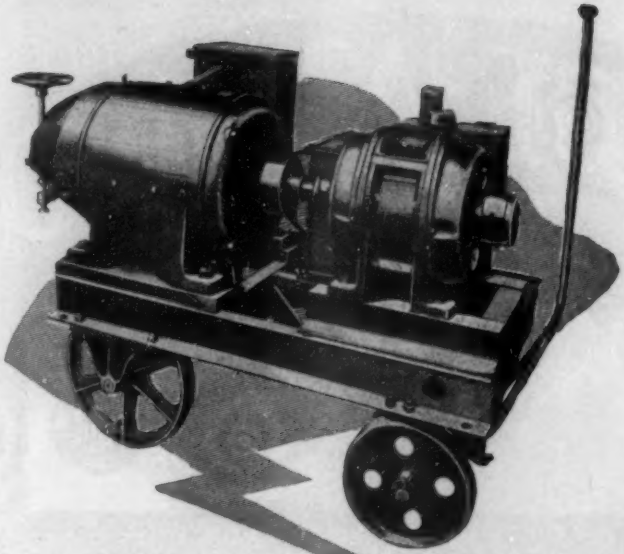

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